



Centre for Advanced Engineering
University of Canterbury



Progress Report to Donors

Period from Establishment to 30th June 1994





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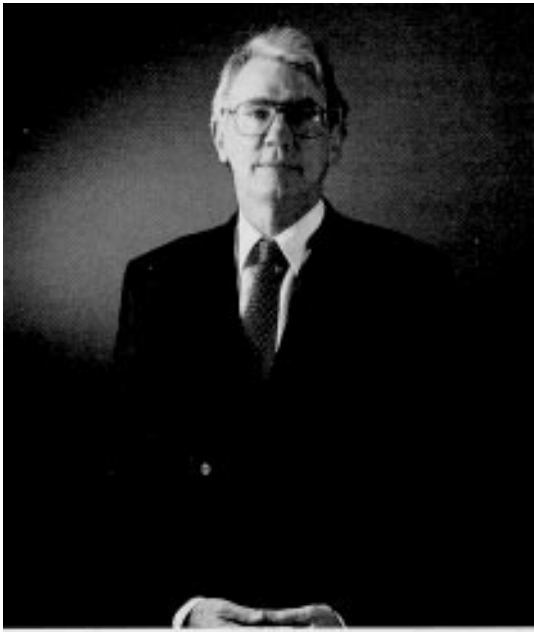


***Centre for Advanced Engineering
University of Canterbury
August 1994***

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Chairman's Foreword



Gavin Cormack, Executive Director of Beca Carter Hollings and Ferner Ltd and Chairman of the CAE Board of Directors.

I am pleased to introduce this report prepared for donors on the activities to date of the Centre for Advanced Engineering. The Centre was established following a fundraising appeal in May 1987 to mark the centennial of the School of Engineering at the University of Canterbury.

I am sure that the results of projects completed by the Centre so far, as described in this report, will demonstrate that the Centre has more than fulfilled the early expectations of many people at the time of the fundraising appeal for the Centre and its subsequent establishment in 1988.

The financial contributions made by the many donors, both corporate and personal, are gratefully acknowledged and all donors are listed in this report. Their generosity has made possible the establishment of the Centre and its achievements to date and has provided a platform upon which to build for the future.

Special thanks are due to Mr Peter Menzies, who chaired the Board of Directors almost from its inaugural meeting in July 1988 until October 1993. The Centre benefited greatly during this period from his wise counsel and able chairmanship. The major contribution made to the establishment of the Centre by Mr Bob Norman, as Chairman of the Fundraising Appeal Committee, by Sir John Ingram and Dr John Robinson, who led the Fundraising in Auckland and Wellington respectively, and Mr George Bridges, who was co-ordinator for the Appeal, are also gratefully acknowledged.

Rent- and maintenance-free premises have been provided to the Centre by the University of Canterbury as its contribution to the Appeal, and these have been considerably upgraded in recent months. In this way, the University has made a very substantial ongoing commitment to support the work of the Centre. The University has also been responsible for the administration of the finances of the Centre and the wise investment of its Trust Fund.

I would also like to express my thanks to my fellow members of the Board of Directors, who have given freely of their time and experience on a voluntary basis, and the staff of the Centre for their energy and dedication to its work.

I hope that you will read this report with interest and if you require any further information on the Centre or its projects, this can be obtained by writing to the Executive Director, John Blakeley.

*Gavin Cormack
Chairman
CAE Board of Directors*

Introduction

The Centre for Advanced Engineering is the centennial project of the School of Engineering at the University of Canterbury and was established by means of an appeal fund launched in conjunction with the centennial celebrations held in May 1987. Approximately \$1.9 million, contributed by 148 corporate donors and 711 individual donors, has been raised to date, plus accumulated interest on the fund. The earnings from the trust are used to fund the Centre's activities.

The Centre's objective is to enhance engineering knowledge within New Zealand in identified areas judged to be of national importance and to engage in technology transfer of the latest research information available from overseas. The Centre is not concerned with basic engineering research, but with the application of research findings to engineering problems.

The main activity to date has been an annual major project, although the Centre has also undertaken smaller projects on engineering subjects of current concern and arranged lectures and seminars on appropriate topics as the occasion has arisen.

For each activity, the Centre brings together practising and research engineers and experts in the particular field from throughout New Zealand and, in the case of the major projects, from overseas. The Centre thus provides a unique forum for co-operation and interaction between industry, the engineering profession and university research engineers.

Since the Centre's inception, three major projects have been completed, and the fourth is now well advanced.

The Centre is managed by a Board of Directors made up of representatives from industry, the engineering profession and the University of Canterbury. The Board was chaired by Mr Peter Menzies of Auckland from 1989 to October 1993. Mr Gavin Cormack of Auckland is the current Chair.

*Prime Minister Jim Bolger
speaking at the launch of the CAE
Energy Efficiency Workshop in
Wellington, February 1994.*



Board of Directors and Staff

The Deed of Trust of the Centre defines the composition of the Board of Directors as the Chancellor, Vice-Chancellor and Dean of the Faculty of Engineering of the University of Canterbury; the Heads of Department of the Faculty of Engineering; and not less than six or more than twelve other people engaged in industry and/or commerce.

The current composition of the Board (and year of first appointment) is:

Directors from Industry and/or Commerce

- 1990 Mr L G Cormack, Beca Carter Hollings and Ferner Ltd, Auckland (Chair)
- 1994 Mr J F Boshier, Capital Power Limited, Wellington
- 1988 Sir John Ingram, Auckland
- 1990 Mr P D Leslie, Wellington Regional Council
- 1994 Mr A M McConnell, McConnell Dowell Corporation, Auckland
- 1993 Mr D A Middleton, Earthquake Commission, Wellington
- 1992 Mr J C Rutledge, Works Consultancy Services Ltd, Wellington
- 1990 Mr A Tait, Tait Electronics Ltd, Christchurch
- 1993 Dr W S Wakelin, Kingston Morrison Ltd, Wellington
- 1990 Mr J R Williams, Production Engineering (NZ) Limited, Marton

Members from the University of Canterbury

- 1992 Mr I D Leggat, Chancellor
- 1988 Professor R Park, Deputy Vice-Chancellor (representing the Vice-Chancellor since 1993 and formerly HOD Civil Engineering)
- 1988 Assoc Professor A J Sutherland, Dean of the Faculty of Engineering
- 1988 Mr J P Blakeley, Executive Director
- 1989 Mr J L Lumsden, Projects Director

Heads of Departments of the Faculty of Engineering

- 1989 Chemical and Process Engineering — Assoc Professor W B Earl
- 1993 Civil Engineering — Dr N Cooke
- 1990 Electrical and Electronic Engineering — Assoc Professor P T Gough
- 1994 Mechanical Engineering — Dr R K Green
- 1993 Natural Resources Engineering — Professor L R Richards (Lincoln University)

Former Members of the Board of Directors

The Centre for Advanced Engineering acknowledges with gratitude the contribution of time and experience made to the work of the Centre by the following former members of the Board of Directors:

Former Directors from Industry and/or Commerce

- 1989-1993 Mr P F Menzies (Chairman of the Board), formerly Mainzeal Group Limited

1988-1993	Mr J H Vernon (Deputy Chairman of the Board), formerly Wellington MED
1988-1991	Mr M J R Allwood, formerly Earthquake and War Damage Commission
1991-1992	Mr W T Bishop, formerly Works and Development Services Corporation Limited
1988-1993	Mr G W Butcher, formerly Morrison Cooper Limited
1988-1994	Mr D J L Chetwin, representing McConnell Dowell Corporation Limited
1988-1989	Mr K A Grantham, formerly Works and Development Services Corporation Limited
1992-1993	Mrs D J Kennedy, formerly Earthquake and War Damage Commission
1988-1994	Professor R F Meyer, University of Auckland (representing Electricity Corporation of New Zealand)

Former Members from the University of Canterbury and the Faculty of Engineering

1988-1990	Professor J Arrillaga, formerly HOD Electrical and Electronic Engineering
1988-1991	Mr R H Bowron, formerly Chancellor
1988-1992	Professor A D Brownlie, Vice-Chancellor
1991	Professor D G Elms, Civil Engineering
1993	Professor L A Erasmus, formerly HOD Mechanical Engineering
1988-1992	Professor H McCallion, formerly HOD Mechanical Engineering
1989-1992	Dr D J Painter, Natural Resources Engineering (Lincoln University)
1988-1989	Professor G T Ward, formerly HOD Natural Resources Engineering (Lincoln University)

Staff

Executive Director	Mr John Blakeley (joined October 1988)
Projects Director	Mr John Lumsden (joined October 1989)
Projects Officer	Mr Charles Hendtlass (joined July 1992)
Journalist	Ms Janine Griffin (joined November 1992)
Secretary	Mrs Sheldine Stewart (joined August 1992)

The Centre for Advanced Engineering

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Executive Director's Report



Executive Director John Blakeley

After the excitement of the May 1987 centennial celebrations of the School of Engineering and the accompanying fundraising campaign to establish a Centre for Advanced Engineering, there was a quiet period while the funds promised over a five-year period began to build up to the point where the Centre's activities could commence.

On 1 October 1988, I took up my appointment as Executive Director with the challenge of translating into action the exciting concept for the Centre that had been widely promoted during the fundraising campaign. On 28 July 1988, the CAE Board of Directors had held its first meeting and considered a number of different proposals for the first major project. Over the next few months, I developed the concept of *Lifelines in Earthquakes* as the Centre's first major project and authorisation to commence work on the project was given at

the second Board meeting held in April 1989. At the same time, approval was given to develop proposals for the Centre's first two smaller projects *Structural Precast Concrete in Buildings* and *Risk Assessment of Industrial and Natural Hazards*.

In October 1989, I was joined by John Lumsden as Projects Director, and from then on a continuing programme of both major projects and smaller projects has been developed and seminars and lectures have been arranged on appropriate topics as opportunities arose. This report summarises all the activities of the Centre that have been completed to date over the period of nearly six years since the Centre's office was first established.



Projects Director John Lumsden

I had the opportunity to visit the Warren Centre for Advanced Engineering at the University of Sydney in May of 1989 and again in June 1990 and August 1993. These visits were very useful indeed as the original concept of CAE was based on the success of the Warren Centre, which was established in 1981 with a similar fundraising appeal. Although CAE has evolved somewhat differently from the Warren Centre, the helpful assistance given to me during those visits is gratefully acknowledged.

The successful completion of the projects undertaken by CAE to date, summarised in this report, has depended very largely on being able to involve a wide variety of people with particular engineering and related expertise. Most of these people have given of their time very generously on a voluntary basis, and I would like to express the grateful thanks of the Centre

to these people and their employers for giving this time, which, if costed on a full professional basis would amount to several millions of dollars. Many of these people have told me of the benefits they have personally derived from participating in the projects. Obviously, there has been two-way benefit in their involvement.

Finally, I would like to express appreciation to our 25 overseas visitors, listed on pages 34-35 of this report, who have participated in CAE projects and seminars to date. They have helped us achieve the original goal of bringing to New Zealand the latest technical information available overseas on the particular topic being studied and transferring this information to the many New Zealand engineers and other professionals who have participated in our projects, workshops and seminars or who have purchased and studied our various publications.

I look forward to the Centre's future with confidence in building on the base that has already been established.

John Blakeley
Executive Director

Major Projects

Major Projects to date:

1990/91	<i>Lifelines in Earthquakes</i>
1991/92	<i>Our Waste: Our Responsibility</i>
1992/93	<i>Reliability of Electricity Supply</i>
1993/94	<i>Energy Efficiency: Our Future</i>

Major projects are the Centre's main sphere of activity. One is carried out each year, and the results are published in two parts. The first, the Project Report, presents the work of the project in detail. The second, the Project Overview, provides a brief summary of the work and major recommendations of the project and is intended for a wider audience than the Project Report.

The Centre's objective is achieved for each major project by bringing together a selected group of practising and research engineers and experts in the particular field from both New Zealand and overseas to:

- consolidate existing knowledge
- study advanced techniques
- develop approaches to particular problems in engineering and technology
- disseminate findings through documentation and public seminars.

The topic of each major project is agreed by the Board of Directors, who approve the level of funding. A Steering Committee is appointed to carry out the initial detailed planning for the project and then provide overall direction. The Steering Committee appoints Task Group Leaders and a Project Manager.

Detailed work on the project is carried out on a voluntary basis by the members appointed to each Task Group, and each Task Group prepares a draft report for discussion at a Project Workshop.

The Centre also arranges to bring overseas experts to New Zealand as Visiting Fellows to ensure that the project incorporates the latest developments on the project's topic. The Visiting Fellows comment on the draft reports and participate in the Project Workshop. The Centre also arranges for the Visiting Fellows to speak at seminars while in New Zealand, which gives a wider audience an opportunity to learn more about the Project and helps to fulfil the Centre's objective of disseminating findings to the public.

The essential purpose of the Project Workshop is to debate the content of the draft reports in an open forum. Following the Workshop, the draft reports are revised and compiled into the Project Report. A summary is prepared and is published as the Project Overview.

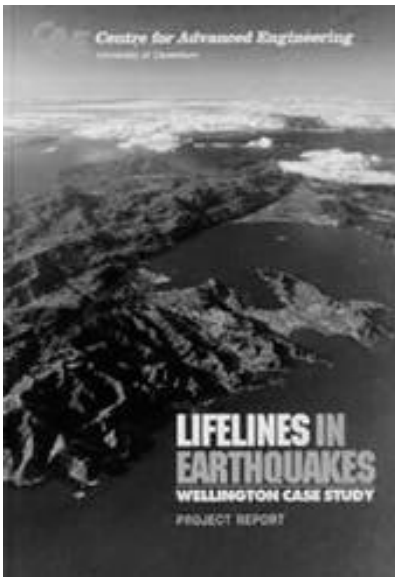
To date, three major projects have been completed. They are:

- *Lifelines in Earthquakes: Wellington Case Study*
- *Our Waste: Our Responsibility — Towards Sustainable Waste Management in New Zealand*
- *Reliability of Electricity Supply.*

The fourth major project, *Energy Efficiency: Our Future*, is currently well under way and will be completed early in 1995.

Lifelines in Earthquakes

Wellington Case Study



Lifelines are those services vital to the running of day-to-day life and include water, gas, electricity, telecommunications and transportation networks. The 1990/91 major project, CAE's first, aimed to assess the vulnerability of these lifelines, identify mitigation measures and raise awareness amongst lifeline managers. Although the project focused on Wellington, the findings are applicable to all urban centres within New Zealand.

Technological developments in recent years mean that society has become increasingly dependent on lifeline services. Wellington's lifelines present the ideal study situation as most, if not all, factors affecting lifeline services in an earthquake are present in a city and region of manageable size.

Wellington is uniquely vulnerable in an earthquake as the city is crossed by several major active faults. Its steep topography and proximity to the sea mean that many of the city's lifeline services are channelled into narrow corridors where potential hazards, such as fault movement, landslips, ground subsidence and soil liquefaction, could occur during a major earthquake. Water, gas, electricity and telecommunication systems traverse faults and areas of unstable soil. Road and rail transport lead only to the north, thereby limiting the number of alternative access routes and Wellington's airport is sited on an area subject to uplift. The harbour mouth is constricted and large areas have been reclaimed for commercial development of the city and the port.

Project Organisation

A steering committee was established in 1989 under the chairmanship of Stuart Macaskill, the Chairman of the Wellington Regional Council. Dr David Hopkins of Kingston Morrison Ltd was Deputy Chairman and Wellington consulting engineer John Norton was appointed Project Manager. Five task groups were set up and task group leaders appointed as follows:

- **Geology and Geomechanics** (Dr Ian Brown — Ian R Brown Associates Ltd)
- **Building Services** (Keith Gibson — Beca Carter Hollings and Ferner Ltd)
- **Civil Services and Gas** (Ray Burrell — Consultant, formerly with Wellington City Council)
- **Electrical and Telecommunications Services** (Lee Goddard — Capital Power Ltd, formerly with Hutt Valley Energy Board)
- **Transportation Network** (John Allard — Wellington Regional Council).

The Visiting Fellows who participated in the project were:

- **Donald Ballantyne** — Dames and Moore Inc, Consulting Engineers (Seattle, Washington)

Lifelines are those services vital to the running of day-to-day life. Wellington's lifelines present the ideal study situation as most, if not all, factors affecting lifeline services in an earthquake are present in a city and region of manageable size.

Lifelines in Earthquakes

Task Groups:

- *Geology and Geomechanics*
- *Building Services*
- *Civil Services and Gas*
- *Electrical and Telecommunications Services*
- *Transportation Network*

Visiting Fellows:

- *Donald Ballantyne — Dames and Moore, Consulting Engineers (Seattle, Washington)*
- *Professor Ian Buckle — State University of New York (Buffalo)*
- *Dr Dennis Ostrom — Southern California Edison Company (Los Angeles)*

• **Dr Ian Buckle** — Professor of Civil Engineering, State University of New York (Buffalo) and Deputy Director, National Centre for Earthquake Engineering Research

• **Dr Dennis Ostrom** — Consulting Engineer, Southern California Edison Company (Los Angeles).

Project Work

The Geology and Geomechanics Task Group defined the nature and extent of the earthquake hazards in the region against which the other task groups could test the vulnerability of the various lifeline services. The other four task groups described each lifeline network and its components and assessed the vulnerability of each component to the identified earthquake hazards. They also considered the consequences of the failure of the components at risk and recommended engineering mitigation measures.

Assessment of vulnerability was made for two levels of earthquake, a “design level event” and a “maximum credible event”. The design earthquake was defined as a regional earthquake of Modified Mercalli 8 (MM VIII) intensity, without local fault movement, likely to cause peak ground accelerations of 0.3g anywhere in the region. The probability of such an event was assessed as about 50 percent in 50 years. The maximum credible event was related to movement on the Wellington Fault that would cause an earthquake of Modified Mercalli 10 (MM X) intensity and local peak ground accelerations of 0.9g attenuating away from the fault. The probability of the maximum credible event occurring was assessed as about 10 percent in 50 years.

An important aspect of the work was an analysis of the interdependence of each lifeline upon the others. The analysis highlighted the fundamental importance of roading, standby power, fuel supply and telecommunications to all lifelines and the high dependency of building services, air transport and broadcasting on other lifelines.

A three-day Project Workshop was held in Wellington in September 1990 and the Visiting Fellows spoke at several meetings following the Workshop. The Project Report and Project Overview were officially launched in September 1991 at a function held at the Beehive in Wellington.

The contribution of the Earthquake Commission, as principal sponsor, and of eleven other sponsoring organisations is gratefully acknowledged.

Ongoing Work

Since the project's completion, two follow-up groups have been formed.

The **Wellington Earthquake Lifelines Group** was formed in September 1992 to further the work of the CAE project. The group aims to promote Wellington as a centre of excellence in lifeline earthquake engineering and to ensure that the community is well-prepared to function after a major earthquake. A

one-day workshop on mitigation measures in November 1993 drew 140 participants.

The [Christchurch Lifelines Project](#) was established in October 1992 and is using the methodology of the CAE project to assess potential natural hazards in the Christchurch area. In addition to earthquake, the project is examining the impact of flooding, tsunami and meteorological hazards on Christchurch's lifeline services. A one-day workshop was held in March 1994 and will be followed by a three-day workshop in October 1994.

The work of both groups is ongoing and other regions are being encouraged to adapt the methodology and examine the vulnerability of their own lifelines to natural hazards.

Our Waste: Our Responsibility

Towards Sustainable Waste Management in New Zealand



The aim of the 1991/92 major project was to provide a set of guidelines for waste management and to contribute to better management of wastes in New Zealand. Better waste management means not only the appropriate management of wastes already produced but, more importantly, aims to avoid or reduce future wastes at their sources. Better waste management in this sense means less wasting of resources and minimising the risk of pollution from wastes.

This topic was considered timely because of the widespread interest in waste management, both in New Zealand and overseas, and although New Zealand does not have the pressures of high population and the level of industrialisation of other OECD countries, there is still ample scope for improvement in the management of wastes in this country.

Project Organisation

Jenny Boshier, a scientist in the office of the Parliamentary Commissioner for the Environment, chaired the Steering Committee, which was established in 1990. John Feltham, an environmental health consultant, was appointed Project Manager. Four task groups were set up and task group leaders appointed as follows:

- [Waste Minimisation Practices](#) (Dr Margaret Bailey — Ministry for the Environment)
- [Hazardous Wastes: Appropriate Technologies for New Zealand](#) (Norman Thom — Environmental Science, Faculty of Science, University of Auckland)
- [Landfill Engineering Guidelines](#) (Mark Drury — Woodward Clyde NZ Limited)
- [Waste Management in Relation to Water Supplies](#) (Cliff Tipler — Lincoln Ventures Ltd, Lincoln University).

Better waste management means not only the appropriate management of wastes already produced but, more importantly, aims to avoid or reduce future wastes at their sources.

Our Waste: Our Responsibility

Task Groups:

- *Waste Minimisation Practices*
- *Hazardous Wastes: Appropriate Technologies for New Zealand*
- *Landfill Engineering Guidelines*
- *Waste Management in Relation to Water Supplies*

Visiting Fellows:

- *Professor Donald Huisingh — Erasmus University, the Netherlands*
- *Kenneth Simpson — Alberta Special Waste Management Corporation, Edmonton, Canada*
- *David Campbell — Environmental Safety Centre, Harwell Laboratory, UK*
- *Professor Dale Vanderholm — Associate Dean, Agricultural Research Division, University of Nebraska-Lincoln, USA*

Visiting Fellows for the waste management project were:

- **Professor Donald Huisingh** — Erasmus University, the Netherlands
- **Kenneth Simpson** — President and CEO of the Alberta Special Waste Management Corporation based in Edmonton, Canada
- **David Campbell** — Head of the Landfill Research and Management Section, Environmental Safety Centre, Harwell Laboratory, England
- **Professor Dale Vanderholm** — Associate Dean for Agricultural Research and Associate Director of the Nebraska Agricultural Experiment Station at the University of Nebraska-Lincoln, USA.

A three-day Project Workshop was held in Wellington in November 1991 and the Visiting Fellows spoke at a series of seminars in the week following the Workshop. The

majority of the task group work was completed by February 1992 and the final 460-page Project Report and 40-page Project Overview were officially launched in December 1992 at a function held at the Beehive in Wellington.

Project Work

The four topics reflect features in the life-cycle of materials. Waste minimisation practices are concerned with raw materials, their conversion to products and opportunities for reducing or preventing the wastes that arise. Hazardous waste treatment is one of the important steps that needs to be taken before wastes can be safely reused or sent for disposal, and good landfill design and operation are the keys to waste disposal that minimises risks to present and future generations. Finally, the study of wastes in relation to water supplies highlights how wastes returning to the environment may cause pollution that could threaten public health.

The Project Report is presented in five parts.

Part 1, *Common Themes in Waste Management*, considers matters relevant to each of the four topics. The themes covered are Maori cultural values and principles for waste management, risk assessment, legislative framework and public participation.

Part 2, *Waste Minimisation Practices*, identifies and describes management practices and technologies that will minimise the production of wastes in New Zealand and suggests means for their implementation.

Part 3, *Hazardous Wastes: Appropriate Technologies for New Zealand*, addresses the way in which hazardous waste management programmes appropriate for New Zealand can be developed.

Part 4, *Landfill Engineering Guidelines*, provides details of the disposal of

wastes in landfills for the use and benefit of planners, designers, operators and regulators. The guidelines aim to provide an outline of the development and design of landfills and the key procedures involved.

Part 5, *Waste Management in Relation to Water Supplies*, identifies and describes waste management practices and technologies that will ensure that the quality of New Zealand's water supply sources are protected.

The contributions made by the Auckland Regional Council, Ministry for the Environment and 28 other organisations that provided sponsorship for this project are gratefully acknowledged.

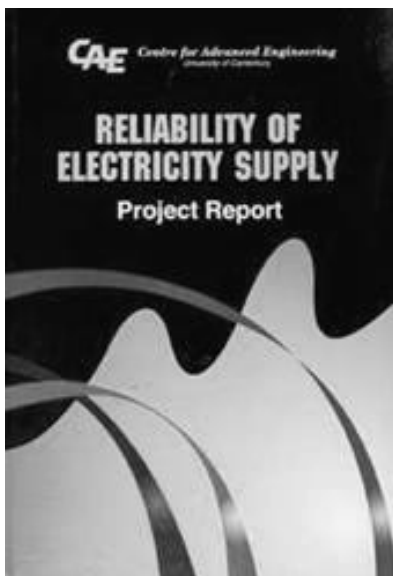
Recommendations and Ongoing Work

A key recommendation of the Project was that the principles of **cleaner production** should be introduced to New Zealand. **Cleaner production**, as defined by the United Nations Environment Programme, is:

“the conceptual and procedural approach to production that demands that all phases of the life-cycle of a product or of a process should be addressed with the objective of prevention or minimisation of short- and long-term risks to humans and to the environment”.

As a result, the Ministry for the Environment set up the **Cleaner Production Task Force** to introduce this concept to selected local industries by way of demonstration projects. Further to this, the Wellington City Council has established a **Cleaner Production Association** to educate and promote the cleaner production concept to industry and commerce in New Zealand.

Reliability of Electricity Supply



Electricity has a 48 percent share of the non-transport energy market in New Zealand, making it the single most important energy source in the country. Supply reliability is an important issue, as electricity consumers in New Zealand have come to expect a constant supply. Furthermore, electricity deregulation has introduced, among other things, competitive energy trading, which may influence relative reliability levels offered by electricity retailers. The Centre's third major project, carried out in 1992/93, studied the reliability of New Zealand's electricity supply.

The project's aim was to provide a set of guidelines to simplify the complexities of electricity supply reliability for customers who wish to make informed decisions regarding the most cost-effective power supply for their needs. As the electricity supply environment becomes more competitive, greater understanding of the factors affecting reliability will be required. This project provides information that will assist customers to make a proper assessment of the available investment options. Project work included a survey of domestic and commercial customers as to the degree of electricity supply reliability they expect.

Reliability of Electricity Supply

Task Groups:

- Customer Requirements
- Delivery
- Generation

Visiting Fellows:

- Dr Roy Billinton — College of Engineering, University of Saskatchewan, Canada,
- Professor Ron Allan — Department of Electrical Engineering and Electronics, University of Manchester Institute of Science and Technology, England

Project Organisation

Geoff Robinson, formerly of the Ministry of Energy, chaired the Steering Committee established early in 1992 and Alistair Robertson, a Christchurch-based consulting engineer, was appointed Project Manager. Three task groups were set up and task group leaders appointed as follows:

- **Customer Requirements** — Neville Ross (Southpower)
- **Delivery** — Tom Leong (formerly of Wairarapa Electricity)
- **Generation** — Robin McKenzie (formerly of New Zealand Electricity Department).

The Customer Requirements task group documented customers' views of electricity supply reliability through surveys, literature research and the knowledge of its members.

The Delivery task group examined aspects of reliability in the transmission and distribution systems.

The Generation task group examined the technical, managerial and legal aspects of generation as they relate to reliability.

Visiting Fellows were **Dr Roy Billinton**, Associate Dean of Graduate Studies, College of Engineering, University of Saskatchewan, Canada, and **Professor Ron Allan** of the Department of Electrical Engineering and Electronics at the University of Manchester Institute of Science and Technology, England. The Visiting Fellows participated in the Project Workshop in Christchurch in August 1992 and three one-day seminars in Auckland and Wellington in the week following the workshop.

Findings and Recommendations

Reliability relates to the number and severity of supply interruptions customers experience. "Supply interruption" refers to any event on the power supply where the customer is consequently inconvenienced, suffers loss or is otherwise deprived of the ability to continue with normal activities. The fewer and shorter such interruptions are, the more reliable the supply is said to be.

The project report recommends that a national reporting scheme for reliability statistics be established. Three main indices commonly used overseas that are appropriate for New Zealand are:

- SAIDI (System Average Interruption Duration Index)
- SAIFI (System Average Interruption Frequency Index)
- CAIDI (Customer Average Interruption Duration Index)

Reliability depends on many factors, such as the degree of duplication of electrical plant, spare generating capacity available at the time of an incident, electrical protection equipment used to disconnect a faulty portion of the system, ruggedness of design and construction standards and how well plant and equipment is maintained.

The project work brought together a large body of research work and incorporated current international thinking on issues pertinent to electricity reliability in a framework relevant to the New Zealand environment.

A reliable electricity supply is greatly influenced by the level of expenditure on maintenance and upgrading in the supply system, from the generators through to the customers. In recent times, the approach to this expenditure has changed from one of ensuring that appropriate engineering standards are met to one of ensuring that expenditure is sufficient to maintain acceptable levels of supply reliability.

One of the principle recommendations to emerge from this project was that a [national reporting scheme](#) for reliability statistics from electricity suppliers should be established. The Delivery task group recommended that three main indices be adopted nationally. These indices are commonly used overseas and are:

- [SAIDI](#) (System Average Interruption Duration Index)
- [SAIFI](#) (System Average Interruption Frequency Index)
- [CAIDI](#) (Customer Average Interruption Duration Index).

A final recommendation was that all participants in the electricity industry should use the Project Report as a guide to reliability of electricity supply, particularly in regard to consolidating current practices and standardising reporting methods. Consistency of approach is considered important in the improvement of quality and reliability of supply.

The 47-page Project Overview was officially launched at a function held in the Beehive in Wellington on 20 October 1993. The 367-page Project Report became available for distribution and sale in March 1994.

The contribution of the principal sponsor, Trans Power New Zealand Ltd, is gratefully acknowledged, as are the contributions of the seven other sponsoring organisations.

Energy Efficiency: Our Future

Energy efficiency is the theme of the Centre's fourth major project, which is currently in progress.

In the context of this project, energy efficiency is taken to mean getting greater value from energy use and/or using less energy to achieve the same results. The project aims to examine energy efficiency technologies currently available but not widely used in New Zealand and identify energy efficiency technologies likely to prove practical for New Zealand in the next decade.

Project Organisation

Michael Underhill, Chief Executive of Energy Direct in Lower Hutt, is chairing the steering committee and Chris Collins, Director of the energy and environment consultancy Eden Resources Limited, is the Project Manager. The seven task groups and their leaders are:

- [Domestic Buildings](#) (Mark Bassett — Building Research Association of New Zealand)

Energy Efficiency

Task Groups:

- *Domestic Buildings*
- *Commercial and Institutional Buildings*
- *Transport*
- *Primary Production*
- *Food Processing*
- *Forestry Processing*
- *Manufacturing and Minerals*

Visiting Fellows:

- *Dr Adam Brown — Renewable Energy Department, Energy Technology Support Unit at Harwell, England*
- *Professor Ian Fells — Professor of Energy Conversion at the University of Newcastle-upon-Tyne, England*
- *Stephen Selkowitz — Programme Leader of Building Technologies Department, Lawrence Berkeley Laboratory at the University of California*
- *Professor Daniel Sperling — Professor of Environmental Studies and Civil Engineering and Director of the Institute of Transportation Studies at the University of California, Davis*
- *Martin Thomas — Principal of Sinclair Knight Merz Pty Limited, Sydney, Australia*

- **Commercial and Institutional Buildings** (Bill Brander — Energy Efficiency and Conservation Authority)
- **Transport** (Ian Bone — Beca Carter Hollings and Ferner Limited)
- **Primary Production** (Assoc Professor Ralph Sims — Department of Agricultural Engineering, Massey University)
- **Forestry Processing** (Andrew Peacock — Beca Simons Limited)
- **Food Processing** (Professor Richard Earle — Department of Process and Environmental Technology, Massey University)
- **Manufacturing and Minerals** (Alan Smith — Department of Electrotechnology, Auckland Institute of Technology).

The last three groups originally constituted an industry task group led by Bob Hill of Carter Holt Harvey Limited. Mr Hill now oversees the three task groups.

Five Visiting Fellows have been invited to review the work of the task groups and participate in the project workshop. They are:

- **Dr Adam Brown** — Renewable Energy Department, Energy Technology Support Unit at Harwell, England
- **Professor Ian Fells** — Professor of Energy Conversion at the University of Newcastle-upon-Tyne, England
- **Stephen Selkowitz** — Programme Leader of Building Technologies Department, Lawrence Berkeley Laboratory at

the University of California

- **Professor Daniel Sperling** — Professor of Environmental Studies and Civil Engineering and Director of the Institute of Transportation Studies at the University of California, Davis
- **Martin Thomas** — Principal of Sinclair Knight Merz Pty Limited, Sydney, Australia.

Prime Minister Jim Bolger spoke at the opening function for the very successful project workshop held in Wellington from 21-24 February 1994. The workshop was followed by one-day seminars in Christchurch and Auckland.

The task groups are currently revising their draft reports in light of discussions at the project workshop. It is expected that this project will be completed early in 1995.

The contribution of the project sponsors, the Electricity Corporation of New Zealand and the Natural Gas Corporation, is gratefully acknowledged, and thanks are also given to the Energy Efficiency and Conservation Authority and the project supporters for their financial contributions.

Other Activities

Smaller Projects and Seminars

The Centre also undertakes smaller projects and holds seminars on engineering topics of current concern whenever the opportunity arises. Smaller projects generally result in the publication of a project report and the proceedings of seminars are sometimes published. The Centre also distributes notes taken during seminars, when available.

Smaller projects to date are:

- The Use of Structural Precast Concrete in Buildings
- Risk Assessment of Industrial and Natural Hazards
- Electricity Supply and Demand to 2010
- Quality Assurance Systems for Smaller Manufacturers
- Fire Engineering Design Guide.

Seminars that have resulted in publications are:

- Sustainable Management and the Resource Management Act
- State-Industry-University Linkages.

Smaller Projects

Structural Precast Concrete in Buildings

Guidelines for the Use of Structural Precast Concrete in Buildings was the first smaller project undertaken by the Centre.

At a 1988 seminar at the University of Canterbury, designers, researchers, fabricators and constructors pointed out the growing need for investigation into the performance of precast concrete in structural members for seismic resistance. As a result, a precast concrete study group was formed by the New Zealand Concrete Society and the New Zealand Society for Earthquake Engineering.

The group's objective was to bring together and summarise existing data on precast concrete use and to present the data in a form useful for New Zealand conditions. The project report was edited by Andrew Charleson of the School of Architecture at Victoria University of Wellington and published by the Centre. Funding was provided by the two societies and CAE.

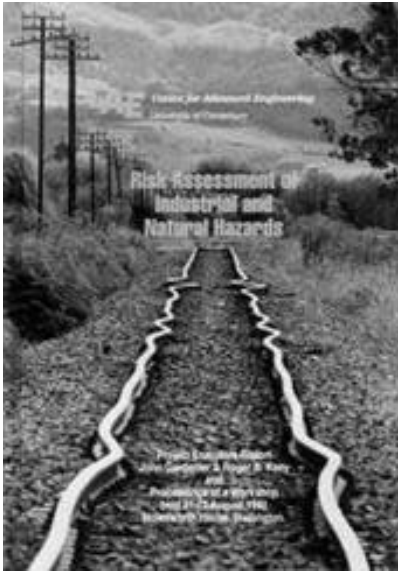
Topics covered in the report include:

- precast beams (shell and solid)
- precast columns and their jointing
- beam-column joints, especially when cast in-place between precast

elements

- support and continuity of floor slabs
- jointing techniques and connectors
- constructability and tolerances
- diaphragm actions
- behaviour of precast concrete wall systems.

The report was published in August 1991. The first print run of 250 copies sold out and a second of 300 copies was produced in June 1992.



Risk Assessment of Industrial and Natural Hazards

The publication *Risk Assessment of Industrial and Natural Hazards* contains the proceedings of a two-day workshop held in Wellington in August 1991 and an executive report written following the workshop by the project leaders, Wellington consulting engineer John Gardenier and Professor Roger Keey of the University of Canterbury's Chemical and Process Engineering Department.

The project's principal objective was to study methodologies underlying estimation of risk and associated public perceptions of hazards. These often differ widely, such as those relating to major industrial accidents, traffic accidents, fire, earthquake, volcanic eruptions, river and coastal flooding, dam failure or general health hazards.

Sixteen papers were presented at the workshop covering risk assessment in various engineering fields, environmental and earth studies, health services, economics, insurance and planning disciplines.

The project was endorsed for registration under the International Decade for Natural Disaster Reduction, which was co-ordinated within New Zealand by the Ministry of Civil Defence. Financial support was provided by the Ministry for the Environment, the Department of Health and the Institution of Professional Engineers New Zealand. The report was published in October 1992.

Electricity Supply and Demand to 2010

This project came about when Leyland Consultants Ltd of Auckland advised CAE that they had developed an electricity generation model that takes into account all existing ECNZ power stations in New Zealand and that can be used for studies of future electricity supply and demand. ECNZ stations supply about 95 percent of New Zealand's electricity demand.

The Centre subsequently commissioned Leyland Consultants to update the model and prepare an initial report as a discussion document. The report

considered only existing ECNZ generating facilities (including the Clyde project) and existing energy sources to determine how these might be used to meet the expected increasing demand for electricity.

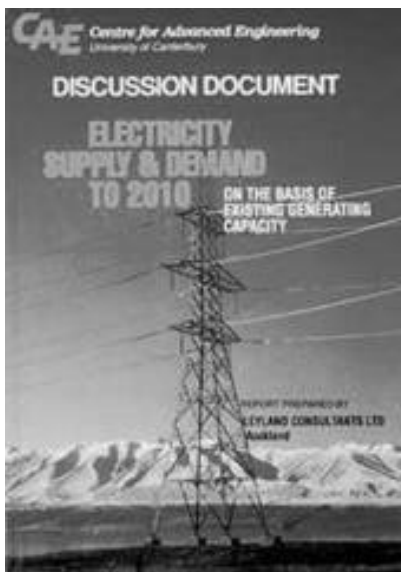
First Edition

The intent of the first edition, published in December 1992, was to show when the existing generating capacity can no longer meet load. Two factors are important. The first is the running down of the Maui gas field between 2007 and 2010 when it can no longer sustain electricity generation. The second is increasing load. When demand can no longer be met, an “energy gap” will occur.

The report assumed an annual growth rate of approximately two percent in electricity consumption, although some consideration was also given to three percent annual growth.

The model predicted that considerable quantities of expensive fossil fuels, including oil, will be required for generation of electricity in existing power stations well before the turn of the century unless an immediate start was made on the planning, design and construction of new power projects.

The report predicted an energy gap in any “dry year” after 1998 if there are losses in existing hydro generation capacity arising from forthcoming water right renewals.



Second Edition

By late 1993, the First Edition had sold out its first print run of 220 copies. The Centre then commissioned Leyland Consultants Ltd to update the report for a second edition, which was released in May 1994.

In the second edition, a higher average annual growth rate of three percent was considered more appropriate in light of present growth in electricity consumption and predicted higher economic growth rates. The first edition assumed that both Meremere and Marsden B power stations could be used to generate electricity as consumption increased. However, it is now unlikely that either station will contribute to future electricity supply and this was taken into consideration in the second edition.

As a result of these changes, the time at which an energy gap is predicted to occur is earlier than in the first edition.

Quality Assurance Systems for Smaller Manufacturers

In August 1991, the Centre commissioned a pilot study on quality assurance with the aim of producing a guide for smaller manufacturing companies that wished to adopt quality assurance systems, particularly the International Standards Organisation 9000 series of standards.



Andrew Shaw, who had completed a thesis on the introduction of quality assurance systems as part of his postgraduate studies in the Department of Mechanical Engineering at Canterbury University, was engaged to carry out the initial work.

The first part of the project entailed a survey of Canterbury manufacturing firms in regard to their current needs in the implementation of quality assurance systems. The survey found that the main motivation behind the introduction of quality assurance systems was customer or contractual requirements for two reasons:

- the number of larger companies with quality assurance systems who require approved suppliers is increasing
- contractual requirements increasingly require demonstration of a supplier's ability through accreditation of their quality

assurance system.

Another reason commonly cited was a desired increase in product quality.

Although companies recognised the need for the introduction of quality assurance systems, it was evident from the survey that the scope and application of the ISO 9000 series was not clear to those considering adopting a quality assurance system. They described their main concerns as lack of knowledge, cost of implementation and the commitment of time and resources to set up the system.

The second part of the project was then undertaken to produce an introductory guide to the implementation of quality assurance systems for smaller manufacturers.

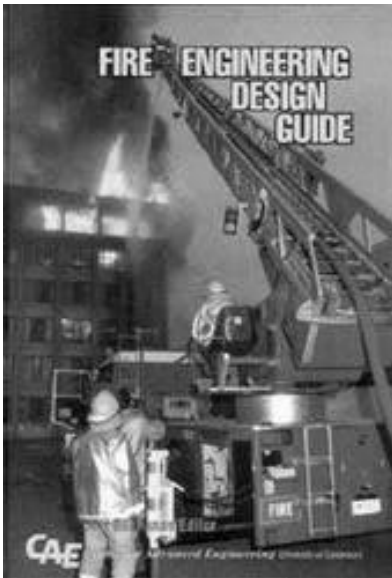
The first two chapters of the guide outline the history and development of quality assurance systems. Chapters 3 and 4 outline the requirements associated with introducing a quality assurance system, ISO 9002 in particular, and briefly describe the certification of a company's quality assurance systems. The final chapter gives information on training, grants and organisations associated with the quality assurance field.

Quality Assurance Systems for Smaller Manufacturers: Introductory Guide became available in November 1993.

Fire Engineering Design Guide

The *Fire Engineering Design Guide* arose from a study group established by the New Zealand Structural Engineering Society and the New Zealand Fire Protection Association.

Fire engineering design of buildings is a large, complex field that is expanding rapidly. A wide range of disciplines are involved as the level of fire safety in buildings is the product of complex interactions between fire growth and spread, extinguishment, building design and human behaviour.



The Guide is an introduction to fire engineering design and was edited by Associate Professor Andrew Buchanan of the University of Canterbury's Civil Engineering Department. It covers active and passive protection measures, compartmentation, smoke control systems, fire protection of structural elements, water supply requirements and detection and suppression systems. Basic strategies and design information supplemented by simple worked examples are also included.

It is seen as a centralised resource and starting point for:

- appropriately qualified people to undertake fire engineering designs for buildings
- Territorial Authorities who will be receiving and assessing fire engineering design submissions under the Building Regulations 1992.

A draft of the Guide was distributed for review in April 1994 and the final publication will be available in July 1994.

Seminars

Seminars Resulting in Publications



Sustainable Management and the Resource Management Act

Sustainable Management and the Resource Management Act, published in February 1993, contains the proceedings of a one-day seminar held at the University of Canterbury in February 1992.

The seminar was intended to develop the concept of sustainable management in the context of the Resource Management Act of 1991 from the point of view of those who will have to implement it in practical engineering and planning situations.

The Resource Management Act promotes the “sustainable management of natural and physical resources” and replaces a variety of previous acts and regulations. It provides a clear and specific framework for the use, development and protection of natural and physical resources.

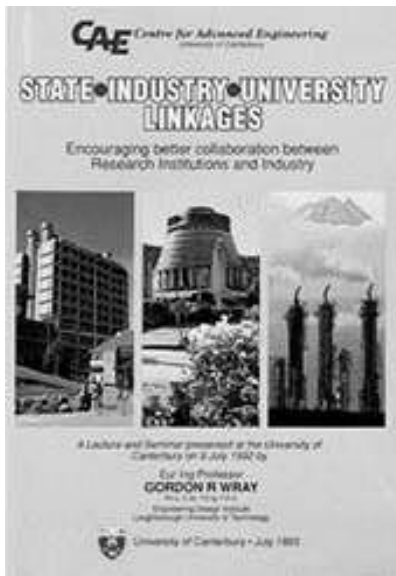
The report of the proceedings includes both the papers presented by the speakers and the discussions that followed the presentations. The first two papers outline the theoretical framework and legislative background to the concept of sustainable management. Two further papers present the perspective of regional and district councils and the balance of the papers give practical examples of sustainable management in relation to the built environment, catchments, groundwater, wastes and energy.

State-Industry-University Linkages

In July 1992, Professor Gordon Wray FRS, of the Loughborough University of Technology in the UK, visited the University of Canterbury. The four-day visit was hosted by the Centre in association with the Mechanical Engineering Department and the Canterbury Branch of the Institution of Professional Engineers New Zealand.

Professor Wray gave four lunch-hour lectures on the following topics:

- “Attaining Competence in Engineering Design at the Undergraduate Level”, followed by an afternoon seminar on “Postgraduate Education and Engineering Design”
- “Design and the National Economy”
- “Academic and Industrial Collaboration in the Design of High Speed and Automatic Machinery”
- “State-Industry-University Linkages”, followed by an afternoon seminar on “Encouraging Better Linkages between Research Institutions and Industry in New Zealand”.



The proceedings of the last seminar and the discussions that followed were published by the Centre in July 1993 as *State-Industry-University Linkages: Encouraging Better Collaboration between Research Institutions and Industry*.

In the first part of the seminar, Professor Wray gave an overview of the British university system and its role in applied engineering research. He discussed the benefits and the difficulties involved in collaborative research and listed some of the successes at Loughborough University.

The second half of the seminar focused on the New Zealand situation. Invited speakers were:

- Dr Basil Walker, Chief Executive, Ministry of Research, Science and Technology

- Angus Tait, Managing Director, Tait Electronics Limited, Christchurch

- John Manning, Manager, Technology for Business Growth Programme, Foundation for Research, Science and Technology.

Each discussed applied engineering research from their own perspective, the strengths and weaknesses of the present system in New Zealand and noted the parallels between the UK and New Zealand as described earlier by Professor Wray.

Other Seminars

Other seminars held since the Centre's establishment in 1988 include:

Flexible Manufacturing Systems (FMS) New Technology for Small Series Production

This seminar, held in Christchurch and Auckland in November 1988, was the Centre's first and was jointly organised by CAE and the New Zealand Heavy Engineering Research Association.

The seminar was planned to take advantage of the visit of two Swedish Professors, Gunnar Kullberg of the University of Lund and Gideon Gerhardsson of the Swedish Employers Confederation. New Zealand engineers Dr Wolfgang Scholz of the New Zealand Welding Centre and Mr John Baker of Machine Tool Specialists Limited provided local input.

The seminar covered recent developments in high technology manufacturing techniques and management strategies used in Sweden. Topics covered included a general introduction to FMS, application of FMS to robot welding systems and laser applications to small series production. Examples of FMS welding and sheet metal working were presented.

Economic Recycling and Conservation of Structures

These seminars were held in Christchurch and Auckland in September 1989. The speaker was Mr Poul Beckmann, a Danish-born British engineer responsible for the protection and restoration of many notable buildings. The seminars were based on the findings of a Warren Centre project on economic recycling and conservation of structures.

Mr Beckmann was the Technical Director of Arup Research and Development in London. Arup advises on structural and constructional problems, and Mr Beckmann has investigated many structural failures, including the collapse of a roof at Leicester University, of aluminium domes near Bradford and of a 275-metre reinforced concrete flue. He specialises in the restoration and rehabilitation of old buildings of outstanding merit, including commercial, industrial and ecclesiastical structures.

While in New Zealand, Mr Beckmann also gave public lectures in Auckland, Wellington and Christchurch describing restoration work on historic buildings in Britain and York Minster Cathedral in particular.

Flexible Manufacturing and Quality Assurance

This one-day seminar was held in Christchurch in November 1989, arranged by the Canterbury Manufacturers Association and CAE.

Dr Ken Whybrew of the Department of Mechanical Engineering at Canterbury University gave a general overview of flexible manufacturing and described a number of examples suitable for New Zealand.

Other speakers gave examples of the application of flexible manufacturing and quality management. The speakers were Mr John Baker of Machine Tool Specialists, Mr Bruce Walters of PDL Industries, Mr Peter Cornes of Tait Electronics, Dr Roberta Hill and Dr Geoff Hall of the DSIR Social Science Unit, Dr Graeme Britton of the Department of Mechanical Engineering at Canterbury University, Mr John Barr of Printpac UEB Filmpac and Mr Noel Stewart of MM Cables NZ Limited.

Fire Safety and Engineering

Three seminars on the Warren Centre's project on building fire safety standards were held in Auckland, Wellington and Christchurch in April 1990.

The speakers at the seminars were Dr Vaughan Beck, Principal Lecturer in Civil and Building Engineering at Footscray Institute of Technology in Melbourne, Dr Caird Ramsay, Principal Research Scientist in the Division of Building Construction and Technology of the CSIRO in Melbourne, and Dr Ian Thomas, the Manager of Engineering R&D at the BHP Melbourne Research Laboratories. Dr Beck was Visiting Fellow for the Warren Centre project and Drs Ramsay and Thomas were leaders of task groups.

The Warren Centre project studied fire safety in Australian buildings and found that a modern systems-based engineering approach that uses computer models can significantly reduce building costs while maintaining current levels of safety.

The seminars were most timely in New Zealand as the Building Industry Commission was carrying out work on a new National Building Code.

Advanced Process Control: Opportunities and Benefits

A one-day course was held in Auckland on 31 August 1990 following the Chemeca 1990 Conference. The course was held as a follow-up to the Warren Centre's project on advanced process control.

Modern process plants use instrumentation and automatic control to ensure safe, steady operation, but need to develop more efficient strategies to remain competitive and develop new market strength. Reduced energy consumption, improved product yields, improved product quality and reduced running costs all improve efficiency, and the course was aimed at providing line and functional managers in the process industries a full understanding of these techniques and their benefits.

The course lecturer was Dr Mike Brisk of ICI Australia Engineering's Advanced Process Control Group. Dr Brisk was a Task Group Leader on the Warren Centre project. He was assisted by Associate Professor Brian Earl and Dr Maurice Allen of the Chemical and Process Engineering Department of Canterbury University.

New Opportunities for Saving Energy in Industry

Dr Greg Ashton of Linnhoff March Limited in the UK was the speaker at these seminars, which were held in Wellington and Auckland in October 1990. Dr Ashton is an expert in the development and application of energy management techniques. He specialises in carrying out process integration studies based on pinch technology, where the main objective is often to reduce energy consumption.

Dr Ashton visited New Zealand after participating as a visiting fellow in a Warren Centre project, "Energy Management in the Process Industries". The seminars were sponsored by DesignPower and arranged by CAE in association with Energy Management (Ministry of Commerce).

Risk Management for Health Protection Officers

Two-day seminars were held in Wellington in October 1990 and again in February 1991 in association with the Department of Health. The seminars were conducted by John Gardenier and Professor Roger Keey.

The objective was to familiarise Health Protection Officers with risk assessment concepts developed in recent years and to show how risk evaluation and management techniques can be applied in the health protection field. Risk quantification, risk perception and overseas risk criteria were among the topics addressed.

The results of these seminars were incorporated into the CAE workshop on “Risk Assessment of Industrial and Natural Hazards” held in August 1991 and the subsequent report.

Identification and Treatment of Waterborne Diseases in Water Supplies

These seminars were held in Christchurch, Wellington, Auckland and Dunedin in late November and early December 1990. Speakers at the seminars reviewed new developments in detecting and controlling pathogens in water supplies. Speakers were Professor John O'Connor, an internationally known drinking water researcher from the University of Missouri-Columbia in the USA, Professor Tim Brown of the Department of Microbiology and Genetics at Massey University and Dr Frank Wilson of the Department of Civil Engineering at Canterbury University. Other speakers from consulting firms, local authorities and area health boards provided information on local water supply issues relevant to waterborne diseases.

Lifeline Services in Earthquakes

Three one-day seminars were held in Christchurch, Wellington and Auckland in April 1992 as a follow-up to CAE's 1990 major project. Professor Tom O'Rourke of Cornell University, USA, a visitor to the Civil Engineering Department at Canterbury University, was guest lecturer. He spoke on lifeline lessons from the 1906 and 1989 San Francisco earthquakes and seismic design considerations for buried pipelines.

The findings of the CAE project were also presented by Dr David Hopkins, the deputy chair of the steering committee for the project, and John Norton, the project manager. Other speakers discussed local issues in relation to lifelines in each of the three regions.

Improving New Zealand's Competitive Edge through Cleaner Production

These one-day seminars were held in Christchurch, Wellington and Auckland in July 1992 and took advantage of a planned visit to Australia by Professor Donald Huisingh of Erasmus University in the Netherlands. Professor Huisingh was previously one of the visiting fellows for the CAE waste management project workshop in November 1991.

Financial Information

A summary of CAE income and expenditure from the time of the fundraising appeal in 1986/87 to the financial year ending 31 December 1993 is presented below. Interest rates obtained on the investment of the Trust Fund were very favourable until 1992, but fell sharply in 1993, reflecting the general decline in interest rates in New Zealand in recent years.

Staff salaries and office running costs are charged to the Centre rather than against individual projects. Income from report sales is credited to individual project accounts together with funds raised especially for those projects.

No general fundraising campaign for the Centre is proposed at the present time, but the CAE Trust Fund remains open for additional donations, which will be most welcome.

Income

	Capital donations	Interest on funds received	Project income	Total income
1986	6,476.00	—	—	
1987	536,277.78	49,597.37	—	
1988	448,941.19	182,004.32	560.00	
1989	325,503.69	270,293.54	2543.47	
1990	222,902.43	316,050.80	193,397.14	
1991	206,176.66	339,784.76	92,619.66	
1992	43,663.87	481,480.18	125,182.47	
1993	75,202.30	170,932.17	101,987.61	
	1,865,143.92	1,810,143.14	516,290.35	4,191,577.41

Expenditure

	Fundraising expenses and establishment costs	Operating expenses (salaries, office running costs and equipment)	Project expenses	Total expenses
1986	24,905.23	—	—	
1987	34,184.82	—	—	
1988	{ 9142.39	10,355.42	854.34	
1989		62,332.19	1695.02	
1990	1333.33	136,203.50	180,775.18	
1991	—	168,134.50	293,579.27	
1992	—	207,043.87	295,482.68	
1993	—	237,730.32	281,003.58	
	69,565.77	821,799.80	1,053,390.07	1,944,755.64
		<i>Balance as at 31 December 1993</i>		2,246,821.77

Corporate Donors

The Faculty of Engineering of the University of Canterbury wishes to acknowledge the generous financial support given to the establishment of the Centre by the following corporate donors. Many of these organisations have had a name change since the time of the fundraising appeal and CAE has endeavoured to give the up-to-date name. Notification of any errors or omissions will be appreciated.

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K W Cory-Wright
Mr H M Cotton
Mr D D Cox

Mr I D Cox	Mr E R Garden	Mr A Howarth	Mr I C Levy
Mr C D Cranfield	Mr G M Garden	Mr J S Howell	Mr W Lewis
Mr P A Crisp	Mr J Gardenier	Mr M W Hughes	W J Lewthwaite
Mr D Cromarty	J C Gardiner	Mr R H Humphrey-	M R Loan
Mr G R Culling	A T Gebbie, Mr	Taylor	Mr G M Logan
Mr N L D'Ath	Mr A Geidelberg	Mr P J Hunt	Mr J W D Lok
Mr G Dainty	Mr A W Gibson	Mr H P Hunt	Mr N S Long
Mr E B Dalmer	Mr A M Gibson	Mr M G Hunter	Mr M D Lough
Mr R J Daniel	Mr E P Giddens	Mr I C Hunter	Mr D R Lovatt
Mr W J Darnell	Mr M D Gifford	Mr J D Huttley	Mr C W Loveridge
Mr R D Davidson	E L Gilchrist	Mr J K Illingsworth	Mr J L Lumsden
Mr J F Davies	Mr A D Glyn-Jones	Mr E R Ireland	Mr E Lust
R W Davies	Mr David Goddard	Mr B J Jackson	Mr R E Lyon
Mr R M Davis	Mr L B Green	Mr R G Jackson	Mr S R MacDonald
Mr R J Dawson	Mr H R Green	Mr C A S Jaques	Mr C E MacGeorge
Mr M C Day	Mr P A Griffin	Mr C M Jarvie	Mr D W Mackenzie
Mr C W Day	Mr K P Grimshaw	Mr M J Jasper	N M Mackenzie
Mr J R de Lambert	R J Guest	Mr G L Jelley	K W MacKenzie
Mr D J de Lisle	Mr A Gulab	Mr P L Jenkins	Mr D K MacLeod
Dr J R de Silva	Mr I W Gunn	Mr S R Jenkins	Mr W MacMillan
Dr John Dean	Mr C W Hall	Mr D G Jenks	Mr M Macphee
Mr J S Dearsly	Mr G J Hall	D W Jenson	Mr R D MacRae
Mr N D Dench	Mr I L Hall	Mr W G Johnstone	Mr J Magyari
G M Dent	H Hall	Mr G M Jones	Prof D R Maidment
Mr G Dewar	Dr T S Halliburton	Mr O T Jones	Mr A S Major
Mr J A W Dimyadi	C Halloumis	Mr L W Jones	Mr J C Major
Mr M Douglass	Mr E P Hambleton	Dr B R E Jones	Mr T F G Mao
Mr J B Downer	Mr M Hanbury-Sparrow	Jones Gray Partnership	P Marks
Mr D G Downey	Mr B B Hands	Mr A H Julian	Mr J R G Marsden
Mr P Drury	Mr N R Hanham	Mr J H Justice	Mr J C R Maycock
Mr M R Dunn	Mr P W Hansen	Mr A L Kampman	Mr D J McBryde
Mr A B Duxfield	Mr D T Hansen	M J Keightley	Mr P J F McCullagh
Mr P H D Edwards	Mr H Hansen	J G Kelly	Mr G R McDermid
Mr S T Emmett	Mr J M Harman	Mr R C Kerr	Mr N G McEwan
Mr C R England	Mr C E Harris	Mr L G Keys	Mr R M McFadden
Prof L A Erasmus	Mr P J Harris	N L Kidd	W L McGlynn
Mr H J Ewens	Mrs P M Harwood	C B Kidson	Mr R McGowan
Mr A M Falconer	Mr D J Hawkins	Mr D W King	Mr R McIndoe
Mr C G M Fallows	Mr J Hay	Mr P King	Mr K D McInnes
Mr A G Fellows	Mr A W Hayward	G W L Kingsley	Mr M S McLean
Mr H C Fennell	Mr W R Heald	Mr S Kingston	Mr J C McLennan
Dr R C Fenwick	Mr C J Heaslip	Mr J H Kirk	Mr L R McLennan
Mr D Ferrier	Mr B W Heesterman	Mr D I Kirkland	Mr N R McLennan
Mr P T Finlay	B Hegerty	Mr G M Knight	Mr K D McLeod
Mr & Miss J Fisher	Dr T D Heiler	Mr E J Knox	Mr N C McLeod
J J Flewitt	Mr E W Heine	Mr M K Korinihona	Mr M E Meads
Mr A Fong	Mr K C Henderson	Mr E Kotlar	L M Megget
Mr N Fong	T J Henderson	Mr P Koutsos	R J Melton
Mr I Fordyce	Mr J H Henley	Mr M R Kurvink	Mr M J L Meyer
B D Forgeson	Mr D W Herd	Mr P M Kusabs	Prof R F Meyer
Mr F B Foster	D G C Herron	Mr P B Lake	Mr R L Meyer
Mr D E Fowlds	Mr M R Hewison	Mr M R Lancaster	L F Meys
Mr A R Francis	Mr M Higgins	N L Lane	Mr R J Mickell
Mr C R Francis	Mr R G Higgins	Mr T F Langrish	Mr P D Middlemiss
I D Franklin	Mr W R Highet	Dr T A G Langrish	Mr S J Miller
Mr R J Fraser	T Hindley	Mr D R Langston	Mr P Millichamp
Mr D B W Fraser	Mr H C Hitchcock	Mr R J Larkins	Mr R A Mills
Mr I A Fraser	Mr D W Hodder	Mr B L Laws	Dr M O Milner
Mr G E Frost	Mr B W Hodge	Mr D B Leadbeater	Mr W Miskelly
Mr R J Fyfe	Mr R J Holbrook	P Leahy	Mr B Mistry
Mr M Galbraith	Mr R G Holmes	Mr R Lee	Mr T N Mitchell
Mr C G Galich	Mr G D Honey	Mr W K Lee	Mr R S Morison
Mr P Gallant	Mr R E Hope	A S Lees	Mr K J Morris
Mr J D Gallen	Mr W D Hopkins	Mr B R Legge	Mr P Morten
J H H Galloway	Mr M C Horsley	C W Leitch	Mr A M Morton
Mr J R A Gammon	Mr C C Howarth	Mr J W Lello	Mr K Morton

Mr R D Moylan	Mr J L E Rountree	Prof P W Taylor	Mr J M Williams
Mr D Murphy	Mr I D Rowden	Mr R J Taylor	Mr M J Williams
Mr M J Murphy	Mr V A Rowland	Mr A E Taylor	Mr P W M Williams
Mr G L Nanson	Mr A W Roydhouse	Mr F T Teague	Mr G J Williams
G T Naulls	Mr P C Rufell	Mr S S Tehara	Mr I A Williamson
Mr A D Nelson	Mr P Rushworth	Mr W B Ten Kley	Dr F Wilson
Mr C R Newton-King	Mr D C Ryan	Mr S Terzaghi	Mr J H Wilson
Mr J B Nicholls	Mr N L Rykers	Mr S Tevita	Mr R H Wilson
Mr R R Nicholson	Mr L T Savage	Mr D Thom	R H Wilson
Mr D A Niven	Mr C R Scarf	Mr B E Thomas	Mr F T Wilton
Mr J A Norton	Mr L P Schwabe	Mr T A Thompson	P J S Winn
Mr D A Nottage	Mr L C Scott	Mr A P G Thompson	R F Winter
Mr G W Nuttall	Mr H Seeto	Mr A J Thomson	Mr P K C Wong
Mr C J O'Donovan	Mr N Sharma	Mr A K Thomson	Mr D Wood
J C Oliver	D A Shaw	Mr H L Thomson	Mr G Wood
Mr J C Orr	Mr I C Shearer	Mr P A Thomson	Mr W I Wood
Mr T J Otley	S R Sheat	Mr P N Thornton	Mr B J Wood
I C Page	Mr J P Shelley	Mr A D Thorpe	N E Wood
Mr D T Palmer	Mr S L Sim	Mr G B Thorpe	Mr D L Wood
Mr R A Pannett	Mr A G Simpson	D S Todd	Mr E R Wright
G N Parker	Mr S K Singh	K H Tomkins	C G E Wylde
Mr J W Parnham	P Singh	Mr A C H Too	Mr S Young
Mr J A Parsons	Mr W M Slater	Mr S N Tooley	M J Young
Mr A R Paterson	Mr G M Smale	Mr D P Topley	
Dr W D O Paterson	Mr J I Smart	Mr I P Torvelainen	
R J Paterson	Mr A L Smith	Mr G E Townsend	
R A Peacocke	Mr R A J Smith	Mr N J Traylen	
Dr N J Peet	Mr S D Smith	Mr G H Treuren	
Mr S T Pemberton	Mr A P Smith	Mr M P Tritt	
Mr C I Perinpanayagam	Mr M W Smith	Mr B G Trueman	
Mr J G Perry	Mr B L Spence	E Tsamandakis	
Mr J D Perry	Dr R H Spiegel	Mr C M Tung	
Mr E V Persen	Mr I E Staples	Mr C R Turner	
Mr P J Phelan	Mr B J Steel	Mr B W Tyer	
Mr N C Pilbrow	Mr E E Stevens	Mr A E Tyndall	
Mr W H Pitt	R P Stevens	Mr A C Van Beek	
Mr R G Powell	B C Stichbury	Mr K Van Nes	
R M Power	Mr W B Stilwell	Dr S Vanischseni	
Mr I R Powlesland	Mr A G Stirrat	Mr W J Veal	
W D Pringle	Mr B C Stichbury	Mr A R Vermey	
Mr A D Pullon	Mr P Stooove	Mr A S Vernon	
Mr P R Purves	Mr T Story	Mr E L Verstappen	
Dr J K Raine	Mr S E Street	J L Vickerman	
Mr J Ralston	M I Stretton	B J Wakelin	
Mr J B Randle	Mr W S Strong	J B Wala	
Mr K Ratcliffe	C R Stuart	Dr B V Walker	
Mr J Rawnsley	Mr W P Studd	Mr G W Walker	
Mr A A Reader	Mr I Sugiyama	P M Walker	
Mr D Reeks	Mr D A Sulzberger	Mr D P Wallace	
Mr J C M Reelick	Mr T J Surrey	Mr H R Wallace	
Mr M G Reid	Mr H E Surtees	M A Wallace	
Mr J L Reweti	Dr V Sutham	J E Walsh	
Mr G Reynolds	Mr J R Sutton	Mr D A Walters	
Mr J M Rhodes	P D G Swan	Mr G A Ward	
Mr A G Richards	Mr B M Swanson	Mr I L Ward	
Prof L R Richards	Mr R F Swarbrick	Mr R M Watson	
Mr R C H Richardson	Mr D F Symon	Mr J C G Watt	
Mr G H Robinson	Mr Z Szymanski	Mr J F Webley	
Mr G N Robinson	Mr J B Tait	Dr H K Wee	
Mr R Robinson	Mr J Talbot	Mr B Weinstein	
Mr W Robinson	Mr S L Tan	Mr L M Wensley	
Dr J V Robinson	Mr P P Tapper	Mr G C S White	
Mr J P F Robinson	Mr S Taumoepeau	Mr M F White	
J L Robinson	Mr K Tay	Mr B R White	
Mr A J Ross	Mr J B C Taylor	Mr R P Whitelaw	
Mr N W Ross	Mr C W Taylor	Mr A J Wildy	

Overseas Visitors Involved in CAE Activities

Major Project Workshops

Lifelines in Earthquakes (September 1990)

- Donald Ballantyne, Dames and Moore, Seattle, Washington, USA
- Professor Ian Buckle, State University of New York (Buffalo) and Deputy Director of the National Centre for Earthquake Engineering Research, USA
- Dr Dennis Ostrom, Southern California Edison Company (Los Angeles), USA

Our Waste: Our Responsibility (November 1991)

- Professor Donald Huisingh — Erasmus University, the Netherlands
- Kenneth Simpson — President and CEO of the Alberta Special Waste Management Corporation based in Edmonton, Canada
- David Campbell — Head of the Landfill Research and Management Section, Environmental Safety Centre, Harwell Laboratory, England
- Professor Dale Vanderholm — Associate Dean for Agricultural Research and Associate Director of the Nebraska Agricultural Experiment Station at the University of Nebraska-Lincoln, USA

Reliability of Electricity Supply (August 1992)

- Dr Roy Billinton, Associate Dean of Graduate Studies, College of Engineering, University of Saskatchewan, Canada
- Professor Ron Allan, Department of Electrical Engineering and Electronics, University of Manchester Institute of Science and Technology, England

Energy Efficiency: Our Future (February 1994)

- Dr Adam Brown, Renewable Energy Programme Co-ordinator, Energy Technology Support Unit at Harwell, England
- Professor Ian Fells, Professor of Energy Conversion at the University of Newcastle-upon-Tyne, England
- Stephen Selkowitz, Programme Leader, Building Technologies Department, Lawrence Berkeley Laboratory at the University of California
- Professor Daniel Sperling, Professor of Environmental Studies and Civil Engineering and Director of the Institute of Transportation Studies at the University of California, Davis
- Martin Thomas, Principal of Sinclair Knight Merz Pty Limited, Sydney, Australia

Seminars

Flexible Manufacturing Systems (November 1988)

- Professor Gunnar Kullberg, University of Lund, Sweden
- Professor Gideon Gerhardsson, Swedish Employers Confederation, Stockholm, Sweden

Economic Conservation and Recycling of Structures (September 1989)

- Poul Beckmann, Arup Research and Development, London, England

Fire Safety and Engineering (April 1990)

- Dr Vaughan Beck, Victoria University of Technology, Melbourne, Australia
- Dr Caird Ramsay, Division of Building Construction and Technology, CSIRO, Melbourne, Australia
- Dr Ian Thomas, BHP Melbourne Research Laboratories, Melbourne, Australia

Advanced Process Control: Opportunities and Benefits (August 1990)

- Dr Mike Brisk, ICI Australia Engineering, Melbourne, Australia

New Opportunities for Saving Energy in Industry (October 1990)

- Dr Greg Ashton, Linnhoff March Limited, Manchester, England

Identification and Treatment of Waterborne Diseases in Water Supplies (November/December 1990)

- Professor John O'Connor, University of Missouri — Columbia, USA

Lifeline Services in Earthquakes (April 1992)

- Professor Tom O'Rourke, Cornell University, Ithaca, New York, USA

State-University-Industry Linkages (July 1992)

- Professor Gordon Wray FRS, Loughborough University of Technology, England

Improving New Zealand's Competitive Edge through Cleaner Production (July 1992)

- Professor Donald Huisingh, Erasmus University, the Netherlands

Publications

1991

Lifelines in Earthquakes — Wellington Case Study

- Project Summary
- Project Report

Guidelines for the Use of Structural Precast Concrete in Buildings

1992

Our Waste Our Responsibility — Towards Sustainable Waste Management in New Zealand

- Project Overview
- Project Report

Risk Assessment of Industrial and Natural Hazards

Electricity Supply and Demand to 2010 — On the Basis of Existing Generating Capacity (First Edition)

1993

Reliability of Electricity Supply

- Project Overview
- Project Report

Sustainable Management and the Resource Management Act

State-Industry-University Linkages

Quality Assurance Systems for Smaller Manufacturers: Introductory Guide

1994

Electricity Supply and Demand to 2010 — On the Basis of Existing Generating Capacity (Second Edition)

Fire Engineering Design Guide

Forthcoming

Energy Efficiency Project

- Project Overview
- Project Report

Edgecumbe Earthquake Review

The Fundamentals of Environmental Engineering Education

Christchurch Lifelines Project Report

Lifelines Damage and Recovery Following the Northridge Earthquake